CHAPTER 6

EFFECT OF ELECTRIC CURRENT

Electric current flow may produce one or more effects. The principle effects are -

(i) heating
(ii) magnetic
(iii) chemical
(iv) physiological

Current in a conductor always causes two of these effects. They are the heating and magnetic effects. If the presence of electric current causes a change in the structure of the material, there may be a chemical effect. Physiological effect relates to passage of electric current in a living body. Only the first three of these effects will be discussed in this chapter.

6.1 HEATING EFFECT

When electrons gain energy from a source and move through a material they collide with other electrons and the atoms of the material. In doing so they lose some of the energy they had gained, this energy being converted into heat energy. This developed heat energy may be detrimental or useful, depending on whether it was intended to generate the heat initially.

(a) Adverse Heating Effects of Electric Current

Conductors are required to carry power from one point to another. These conductors or cables may be bare or insulated. In both cases, the current carrying capacity of the cables depends upon how well the heat generated within the cable may be dissipated. Bare conductors will carry higher currents than insulated conductors of the same cross sectional area, because the insulation restricts the dissipation of the heat in the conductor. Insulated cables are rated at the current carrying capacity that will not cause damage to the insulation due to excessive heat.

When machinery is used to produce electricity or to convert electrical energy to mechanical energy, heat is produced in the conductors of the machine. The power rating of a machine is largely dependant on how quickly this heat may be dissipated. The rating of a machine may be increased by the use of some type of forced cooling to remove heat more quickly.

(b) Electrical Heating Appliances

Electrical energy is often deliberately converted to heat energy so that the heat generated may be used to perform a useful function. Some of the common types of electrical equipment are discussed in the following paragraphs.

Electric Ranges

Modern electric ranges have elements of the radiant coil type. The current carrying conductor runs in the centre of a high temperature alloy sheaf, separated from this sheaf by tightly packed magnesium oxide powder. The shape of the element is shown in Figure 6.1.

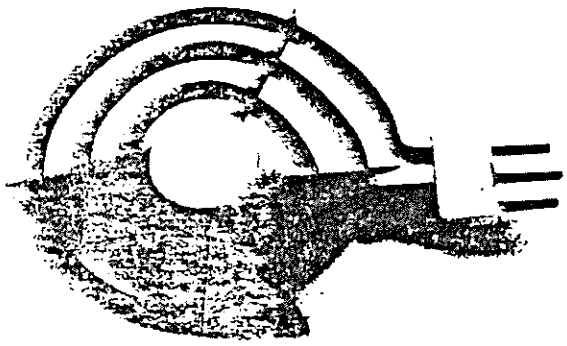

Figure 6.1

The powder acts as an electrical insulator for the conductor, but is also a good heat conductor. The heat generated in the conductor is transferred by the powder to the outer sheafing, then by contact or radiation, to the area to be heated.

Electric Irons

Modern electric irons have elements similar to radiant elements used in electric ranges. The elements have a smaller diameter and are embedded in the ironing plate of the iron. In figure 6.2 an ironing plate has been sectioned so that the position of the element may be seen.

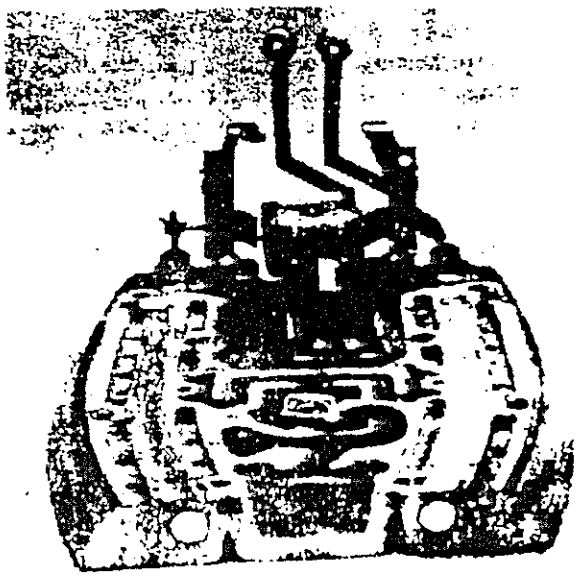

Figure 6.2

This arrangement gives direct transfer of heat from the conductor to the material to be ironed.

Room Heating

The most common form of room heater is the bar radiator. Resistance wire, such as nickel chromium wire, is wound into a long coil. This coil is then stretched, so that adjacent turns are not touching each other.

It is then wound around a porcelain bobbin and the bobbin is placed adjacent to a reflecting area. (Figure 6.3).

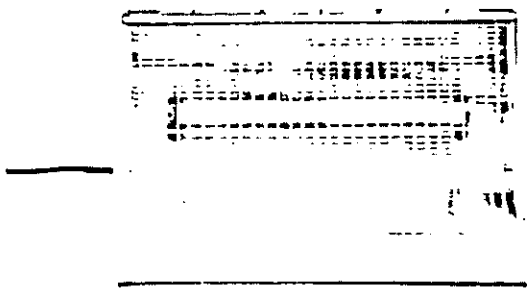

Figure 6.3

Heat is then distributed to the surrounding area by reflection and radiation. This type of heating is highly inefficient. Modern room heaters have the heating element enclosed so that a fan can direct air over the element and onto the area to be heated. (Figure 6.4).

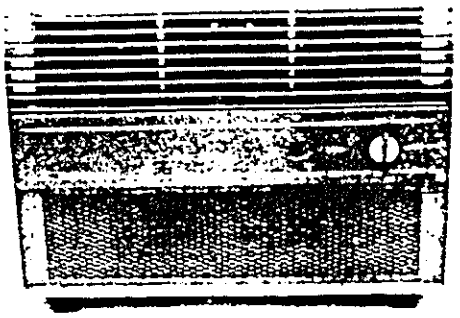

Figure 6.4

The fan is fully enclosed in the heater and draws in already heated air through the bottom opening. The heated air is then again blown over the element and out through the top vent. Due to the recycling of the heated air and the full utilisation of the heating element this type of room heater is very efficient.

Incandescent Lamps

The filament of an incandescent lamp is wound from fine tungsten wire and is so constructed that it is concentrated in a small area. (Figure 6.5).

Figure 6.5

Current in the filament of an incandescent lamp causes the temperature of the lamp to rise in the vicinity of 2000 degrees Celsius. About ten per cent of the heat generated is converted into light which may be used for illumination.

Hot Water Services

Hot water services are either of the instantaneous type or the storage type. In the instantaneous type, hot water is not produced unless it is required for immediate use. The element does not draw current until water is actually flowing from the hot water tap. Current to the element may be switched on or off either manually or automatically. The instantaneous type water heater has no storage capacity, the incoming cold water passing over the heater element before leaving by the hot water tap. A storage water heater is one in which an amount of hot water is kept continuously. Although of a different shape the element composition is the same as that of the hotplate and iron. (Figure 6.6).

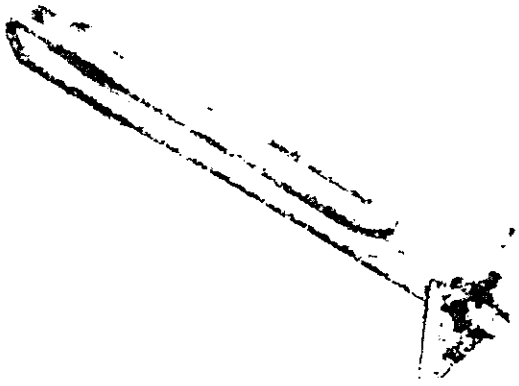

Figure 6.6

The heater element is contained in tanks that vary in capacity from 50 litres to 280 litres. The current to the element is automatically controlled so that the water in the tanks remains at a fixed temperature, thus making hot water available at all times. The times the element is on are usually controlled by the electricity supply authority, and are so regulated that the element operates when the demand on the authority for power is low. For this reason they are known as 'off peak' water heaters. The storage water heater may be a gravity fed type or a mains pressure type. The gravity fed type is usually located above ceiling height while the mains pressure type is located at ground level.

6.2 MAGNETIC EFFECT

Electrons moving in one direction along a conductor create an area of magnetic influence around the conductor. (Figure 6.7).

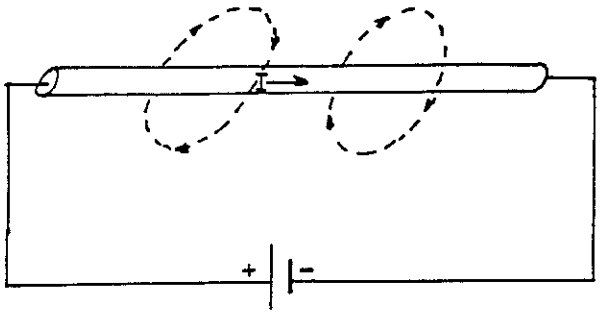

Figure 6.7

The magnetic influence around a single conductor is very weak. In practice the magnetic effect of a current is increased by winding the conductor into a coil. (Figure 6.8).

Figure 6.8

The effect of winding the conductor into a coil (or solenoid, as it is known) is to concentrate the magnetic field through the centre of the coil. (Figure 6.9).

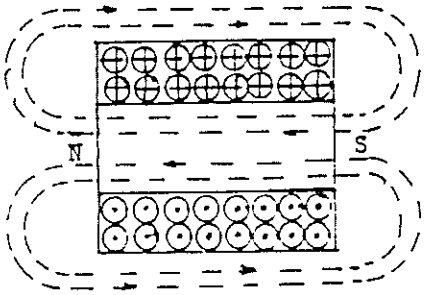

Figure 6.9

The magnetic effect of a solenoid can be further increased by using an iron core with the coil. (Figure 6.10).

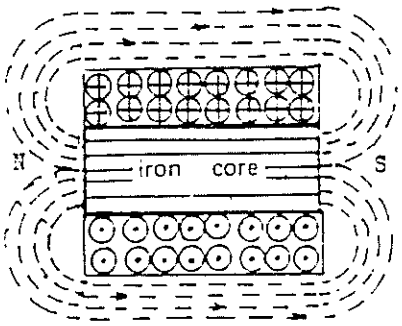

Figure 6.10

The magnetic effect of electric current is used in all types of electrical machinery and has been adapted to operate different types of switching devices such as contactors and relays.

6.3 CHEMICAL EFFECT

Electric current, passing from one electrode through an electrolyte to another electrode, can cause chemical reactions at one or more of the electrodes. In some circumstances an e.m.f. is deliberately applied to the electrodes to cause certain chemical reactions to occur. In others, unwanted chemical cells produce chemical reactions which cause damage or deterioration to the materials acting as the electrodes. These reactions are commonly called corrosion. Electrolytic refining is one of the areas where the chemical reactions at the electrodes are used to produce a certain product. Copper produced by the smelting process contains many impurities which make it unsuitable for some commercial applications. In electrolytic refining the impure copper is suspended in a vat or tank which contains a solution of copper sulphate as an electrolyte. A sheet of refined copper is also placed in the tank and a d.c. supply connected to the two different copper materials. (Figure 6.11).

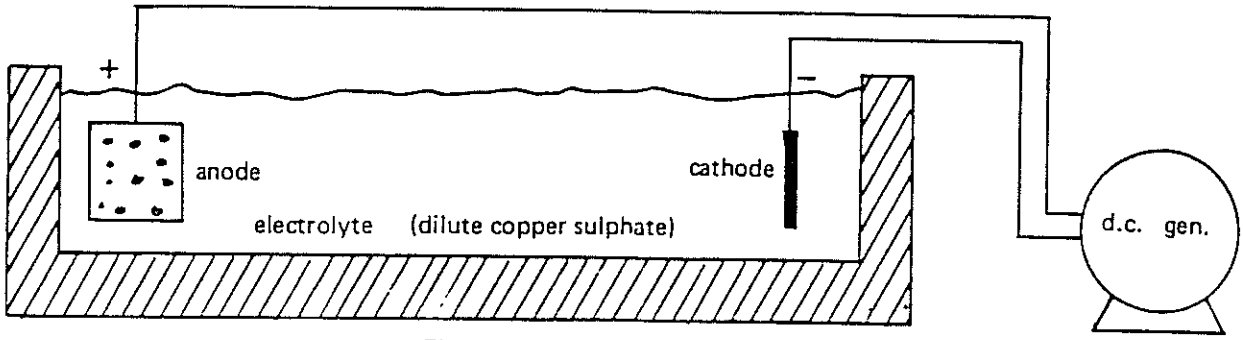

Figure 6.11

The impure copper, known as anodic copper, dissolves into the electrolyte depositing the pure copper on the cathode and the impurities on the tank bottom. Similar chemical reactions are used in electroplating. The article to be plated is used as the cathode in a cell containing a suitable electrolyte such as chromic acid. Current passing through the cell causes chrome to be deposited on the cathode resulting in the bright shiny effect seen on many automobile parts and accessories.

Corrosion, which is the wearing away of a substance from the surface inwards due to chemical reactions, occurs through two different sets of circumstances. In the first instance small electric currents, called 'stray currents', passing through the ground electrically connect buried masses of metal by using the impurities in the damp earth as an electrolyte. This allows current to flow between the two bodies of metal causing chemical reactions on the surface of one or both metals.

In the second case corrosion occurs on metal surfaces due to the impurities on the surfaces of the metal. These impurities, in the presence of an electrolyte (water) become electrolytic cells, causing one of the impurities to go into solution. The most common form of corrosion is rusting which can occur on any ferrous material. Corrosion is deterred or prevented by the use of 'sacrifical anodes' which are in the form of zinc plating (galvanising) or by placing blocks of zinc in the area to be protected. The zinc goes into solution in preference to most other metals if an electrolytic cell is produced.

TUTORIALS 1.6 (Revision)

(1) How long would it take a steady current of 20 amperes to supply 2400 coulombs of electricity to a circuit?

(2) A circuit draws 2.5 amperes from a 200 volt d.c. supply. Determine the resistance of the circuit.

(3) A 6.25 kW element draws 5 amperes from a source of e.m.f. Calculate the resistance of the element.

(4) A hoist raises 200 kg through a height of 270 metres in 7 minutes. Calculate the power rating of the hoist motor.

(5) Determine the power consumed by a 50 ohm resistor connected to a 250 volt d.c. supply.